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GEOLOGY.—*Recent German theories about structural geology.*[1] CURT TEICHERT, University of Freiburg, Germany. (Communicated by CARLE H. DANE.)

The development of new ideas in Germany in the field of structural geology had already begun during the war when as a first impetus Wegener's book *Die Entstehung der Kontinente und Ozeane* appeared. This book has certainly caused more discussion among geologists of all countries than any other book in this line before or since. The fact that it has been translated into many languages and so far has appeared in four editions shows best the deep interest it has aroused everywhere. Although WEGENER'S ideas meet with the objection of the majority of the geologists they certainly have been a great stimulus to the consideration of many questions of structural geology. Since Wegener's book has been translated into English and has been given much attention in English and American literature I shall not enter into any discussion of this theory.

Several attempts have been made to modify Wegener's ideas, most of them by geophysicists who generally have more widely adopted the hypothesis of shifting continents than geologists have done. Only one such attempt has been made on a bigger scale and that by a geologist, RICHARD STAUB, now head professor of geology at the University of Zurich.[2] For a long time Staub has been a very diligent and successful student of stratigraphical and structural problems in the Alps. His *Bau der Alpen*, a comprehensive study of the structure of the Alps, published in 1924, has met with deep interest among European geolo-

[1] Received November 28, 1930.

[2] RICHARD STAUB. *Der Bewegungsmechanismus der Erde.* (Berlin, 1928.) Although Staub is a Swiss geologist, his ideas may be considered in this place because his book is written in German and published in Germany.

gists and many of his conclusions are rather generally accepted by other prominent students in this field. Thus it is entirely natural that Staub should start out from the Tertiary mountain ranges of the earth. He is one of the extreme "Nappisten," one of the believers in that theory founded by ALBERT HEIM that the Alps were built by a series of tremendous overthrusts. Staub himself has done much to strengthen this hypothesis as far as the structure of the Alps is concerned but on the other hand he is inclined to see all the Tertiary mountain ranges of the earth from the same viewpoint as he sees the Alps. He and many other European geologists like to speak of the Tertiary mountain ranges of the earth as "the Alpine mountain ranges." This is a rather dangerous terminology because it suggests not only a contemporaneous origin, but also a building plan and structure for all Tertiary mountain ranges similar to that of the Alps, which is apparently not the case.

Staub studies the Tertiary mountain ranges of the earth, and as a result of these studies he finds that they all form a great uniform system. There is no such thing as the mediterranean system in contrast to a circum-Pacific system, no particular Eastern Asiatic or Australic ranges. All the high Tertiary ranges are a unit. The backbone of this great system is the eastwest trending range of the Alps which continues eastward into the Himalaya and which has also a westward prolongation through the Atlantic ocean to Middle America. (Thus Staub disregards the obvious uniformity of the mid-Atlantic ridge.) In Middle America the main system branches into one great system of mountain ranges trending northward into Alaska and embracing the Pacific ocean on its northeastern side, and into another system trending southward along the west coast of South America and continuing into Antarctica thus embracing the Pacific on its southeastern side. In the same way the eastern end of this central system branches into two minor systems of ranges, one following the northwestern border of the Pacific up to Kamchatka, the other going southward and continuing into the ranges of New Zealand.

As a result one obtains a picture of a great uniform system dividing the main continental masses into two parts, the northern of which is called *Laurasia* and the Southern *Gondwana*, and branching out east and west into gigantic arms which embrace on all sides the big mass of the Pacific ocean. This is the way in which Staub sees connected the great "Alpine" mountain ranges of the earth.

How to explain this picture, is the next question Staub is going to answer. This is certainly not a structure due to a contraction of the

earth. The only explanation of this, as far as he can see, is a shifting of these two big northern and southern masses towards the equator. It is in this respect that he modifies the original theory of Wegener. It is not the continents themselves that are shifting, but only Laurasia and Gondwana, each as a whole and more or less untouched in its interior. For the Teritiary period he regards the southern mass as the active one. All continents of the southern hemisphere (and this includes also India) are shifting northwards, driving back the northern continents and building up at their front the big range of mountains of the mediterranean system. The explanation of the east and west branches of this system is not so very conclusive. Staub speaks of an additional westward drift which has partly caused the great mountains bordering the western shores of North and South America; but of course there is

Fig. 1. Diagram and explanation of the alpine system of the earth. Black: The alpine orogen, with Laurasia in the north and Gondwana in the south. (After R. STAUB.)

the resistance of the Pacific body which can cause the building up of mountains at its borders. For the bottom of the Pacific, Staub supports the idea of Pickering that this is the place where the moon originated; and, moreover, he favors Wegener's idea that the bottom of the Pacific consists of heavier material which is generally supposed to underlie the lighter continents.

What is true for the last mountain-building period must also be true for the preceding ones. One of the main objections made against Wegener's theory is that he disregards the older orogenic periods, chiefly of the Paleozoic. Staub avoids this objection and he draws the following picture that during the history of the earth there were repeated movements of the continental masses of the northern and southern hemisphere (Laurasia and Gondwana) alternately towards the equator

and the poles. He begins with Caledonian time which was a time of continental masses drifting towards the equator. This was followed by a drift towards the poles in post-Caledonian times and this again by a period of drifting equatorward in the late Paleozoic. Again shifted apart in Mesozoic times, the continents turn toward each other in the Tertiary and are now probably drifting apart again.

The force which drives the continents towards the equator if they are situated near the poles is simply the centrifugal force. The collision of the continents near the equator line causes the building up of mountains in the first place and in consequence a displacement of magma below the mountain zones. Thus the magma is forced to flow from the equator on both sides towards the poles and takes the continents with it. This will explain the force which causes the drifting of the continents towards the poles in the intermediate periods between the great mountain-building phases.

Staub's conception of the structure of the earth, thus based on the existence of the *centrifugal force*, *west drift* and the *backflow of the magma* is certainly fine and very simple, but I dare say it is perhaps too simple to be true.

Another geologist trained in the study of the Alps is LEOPOLD KOBER, professor of geology at the university of Vienna. While Staub came to conclusions that were more or less in agreement with ideas of Wegener and were at any rate opposed to any ideas pertaining to a shrinkage of the earth as the mountain building force, Kober claims quite the contrary.[3] Like Staub he is looking for the connection of the Tertiary mountain ranges, but he traces these connections in an entirely different way. He starts with an examination of the mountain ranges of the Tertiary type and comes to the conclusion that fundamentally all known Tertiary mountain ranges are two-sided, that their overthrusts extend northward and southward or eastward and westward, whatever the direction of the mountain range. Moreover he finds out that all Tertiary mountain ranges have a more or less circular arrangement around areas which are not affected by any kind of Tertiary orogenetic movement. He calls this central area the *kratogen* and the surrounding mountains make the *orogenic ring*. Kratogen plus orogenic ring build an *orogen* or a *geotectonic unit*. There are eight of these geotectonic units distinguishable on the surface of the earth: Eurasia, Africa, Indo-Australia,

[3] LEOPOLD KOBER. *Der Bau der Erde*. (Berlin; 1st edition 1921, 2nd enlarged edition 1929.)

North America, South America, North Pacific, South Pacific, and Antarctica.

As an example of such an orogen I shall only give Kober's picture of Africa. Continental Africa itself is the kratogen, largely unaffected by the Tertiary movements. The surrounding orogenic ring consists of the Atlas mountains in North Africa, the Appenines in Italy, some of the mountain ranges of the western and southwestern Balkan peninsula which continue into the ranges along the South coast of Asia Minor and into ranges in Persia. Here the trend of the mountains suddenly changes direction—as Kober assumes—and runs southward,

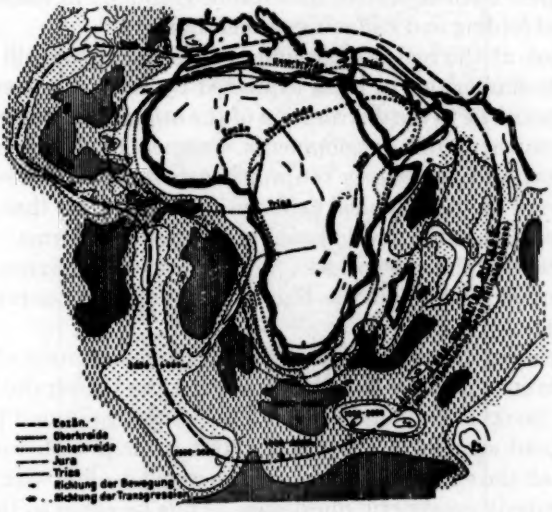

Fig. 2. The African orogen. (After L. KOBER.)

thus striking out into the Indic. All the rest of the orogenic ring of Africa is submerged and consists partly of the eastern half of the mid-Atlantic ridge and of other submarine upliftings of the sea bottom around the African continent. This rather dangerous procedure of tracing structural connections under the sea is applied in a great deal of Kober's constructions.

What, however, is the meaning of the picture thus drawn? Kober is in favor of the idea of the contraction of the earth as the main force of mountain building. If the earth contracts, then a destruction and folding of the surface of the earth cannot take place in certain areas of

resistance, these being stiffened by old intrusions or by former folding processes. The surface can only be folded between and around those areas, and this is the explanation of Kober's picture. The kratogens are the areas of resistance which cannot be folded any more. As soon as the whole body of the earth contracts, these great blocks settle down a little, tending towards the center of the earth. Thus the space between them becomes smaller and the surface between, which is not yet stiff enough, can and must be folded. These are the orogenic rings which surround the kratogens. A similar process also took place in previous times of orogeny. Originally the kratogens were smaller and they grew to their present dimensions gradually in consequence of the gradual folding and stiffening of their borders.

If we look at the real background of these ideas, we will find some remarkable similarities to ideas expressed by R. T. CHAMBERLIN and R. RUEDEMANN as to the distribution of the original ancient continents, although much of the developments assumed by Kober are highly hypothetical and sometimes too much generalized. Kober's aim is largely one of physiographical explanation rather than that of historical consideration of the development of given surface forms. His question is, how to explain the present physiographical configuration of the earth's surface mainly in the light of the latest mountain-building movements.

Another main defender of the theory of the contraction of the earth is HANS STILLE, head professor of geology at the University of Göttingen. His book[4] is undoubtedly one of the most profound books ever written about structural questions. He has made a thorough examination of all the existing literature of the world dealing with structural and particularly orogenetic questions. Thus he came to the postulation of certain tectonic laws.

The first one and certainly that which he regards as the main result of his studies is the *law of orogenetic contemporaneity*, which means that orogenic processes are restricted to certain short periods or *phases* as Stille calls them, and that at those periods orogeny is liable to take place with more or less worldwide distribution. The times between these orogenic phases are absolutely free from any movements of that kind. Only epeirogenesis takes place. The boundary between

[4] HANS STILLE. *Grundfragen der vergleichenden Tektonik*. (Berlin, 1924.) Since Prof. SCHUCHERT has given a long review of this book (Am. Jour. Sci. **12**: 277–292. 1926), Stille's ideas will be considered here only briefly. The multitude of facts and ideas laid down in his book cannot be adequately dealt with in a few sentences anyhow.

epeirogenesis and orogenesis is drawn very sharply by Stille and according to him it is of much importance to distinguish between purely epeirogenetic and purely orogenetic times.

Thus in studying the orogenic movements of the past he establishes between 30 and 40 of those orogenic phases which are distributed in about equal amounts in the Paleozoic, Mesozoic and Tertiary.

Among the orogenic movements he distinguishes two kinds: first the *Alpine type*, consisting of folds, overfolds, and overthrusts; second the *Germanic type*, consisting of fault-fold mountains and block

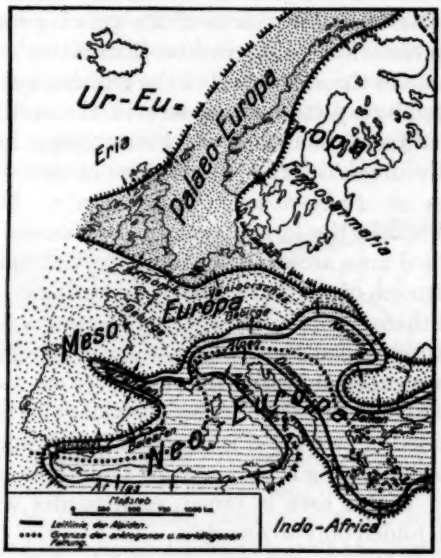

Fig. 3. The tectonic structure of Europe. (After H. STILLE.)

mountains. Both are orogenic and both kinds of movements may occur at the same time in different regions during orogenic phases. Even Stille, however, cannot neglect the fact that there are sometimes orogenic movements during epeirogenic times, but he thinks they are of minor importance and calls them *synepeirogenetic movements*. On the other hand epeirogenic movements during orogenic times, also always of minor importance, are called *synorogenic movements*.

The *law of the contemporaneity of orogenic forms* expresses the fact that all kinds of orogenic movements may occur at the same time and

the *law of the identity of orogenic force* holds that the same force causes all kinds of orogeny. This force is the contraction of the earth.

Like Kober, Stille claims that certain areas are more fit for orogeny than others and especially he thinks that a stiffening by former orogenies prevents a certain area from being folded again. As soon as a region has experienced the Alpine type of orogeny with folding and overthursts, it can only be affected by the Germanic type in later orogenies. Thus only the border regions of these stiffened blocks can be folded, but not the interior, and the result is the steady growth of the stiffened blocks which cannot be folded any more. This conception is very similar to Kober's ideas of the growing kratogens, but is more founded on historical considerations than Kober's were.

How Stille came to the conclusion of the growing continental blocks may be illustrated by a picture of the structural conditions of Europe. There are the stiffened blocks of the Precambrian in the North as *Archeurope* ("Ureuropa"), the Caldonian ranges folded in early paleozoic times as *Paleo-europe* ("Paleuropa"), Middle Europe, folded and stiffened in the late Paleozoic, as *Meso-europe* and finally the recently folded area around the Mediterranean sea as *Neo-europe*. Thus a steady growth of the European block during geologic times has taken place and there remains only one mobile area at the present time, the present Mediterranean sea. This process of progressive folding of the borderlands is called by Stille the *folding of the frames* and plays a great rôle in his considerations. The question whether the orogenic zones are one-sided or two-sided is of minor importance to Stille. If the area affected by folding is very narrow then there would be a two-sided pressure. If this area is broad, each border will appear as a separate branch folded only to one side.

I cannot refer to the many details of Stille's book and I have to omit even some of the more important questions touched upon by him. I may say a few words more about his definitions. If we speak, for instance, of a geosyncline, we think immediately of an area of more or less intensive folding after the deposition of sediments there. This, according to Stille, is a misconception and he defines a geosyncline as any depressed area of large extent with sinking tendency thus accumulating large amounts of sediments, regardless of its later development. There are a number of geosynclines on the earth which never have been folded or affected by any type of Alpine orogeny. This is an important and decided step towards the liberation of the word "geosyncline" from the burden of partly or wholly wrong conceptions which it has carried now for decades.

To summarize Stille's opinions: tectonics is a function of the intensity of the tectonic force, of the capability of reaction of the material involved and in certain cases of particular local conditions. The only tectonic force is the contraction of the earth which does not take place steadily, but abruptly at certain phases; and every time the shrinkage of the earth causes worldwide orogenic movements. Thus for Stille the site of orogeny is the outer crust of the earth and the cause of orogeny are processes which pertain to the whole body of the earth. If subcrustal magmatic material is involved in orogenic processes, this can be only secondary. Stille neglects the importance of isostasy, as well as the magma; in fact, isostasy is hardly mentioned in his book.

The antithesis of these ideas is the basis for the most recent theory promoted in Germany by ERICH HAARMANN, geologist of the Prussian Geological Survey. It is remarkable that in a comparatively short period after the appearance of Wegener's revolutionary book, such a book, not less revolutionary and yet on entirely different suppositions

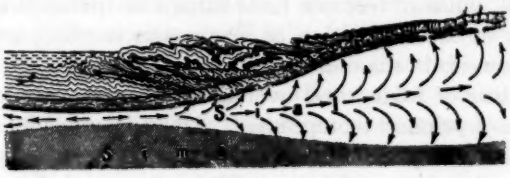

Fig. 4. The formation of a geotumor and free gliding. (After E. HAARMANN.)

has appeared.[5] Like Wegener, Haarmann abandons most of the conceptions formerly regarded as sure and irrefutable and enters into a discussion of the fundamental principles of our science. For him, the main force which causes diastrophism at the surface is the movement of the subcrustal magma. This flows from one place to another, causing uplifting of the crust where it is accumulating and depressions where it is streaming away. Therefore the influence of such magmatic movements upon the behavior of the outer crust causes the appearance of widespread up-and-down movements. Haarmann calls an uplifted area a *geotumor*, a depressed area a *geodepression*, terms which correspond largely with "geoanticline" and "geosyncline." Thus Haarmann is going a step farther than even Stille, who confined himself to a redefinition of these old expressions. But in fact a geotumor is not exactly identical with geoanticline and a geodepression not exactly like a geosyncline as we shall see.

[5] ERICH HAARMANN. *Die Oszillationstheorie.* (Stuttgart, 1930.)

The building of geotumors and geodepressions is a steady process which is always taking place somewhere. Haarmann seeks the cause of this eternal up and down, or rather of the movements of the subcrustal magma which causes this, in oscillations of the axis of rotation of the earth which give rise to changes of the balance between the masses of the earth and thus force the masses to change their position.

One may however regard this as a doubtful explanation. It is not at all the main point with which the theory of Haarmann is concerned.

Another old conception abandoned by Haarmann is the strong distinction made so far between epeirogenesis and orogenesis as two different kinds of movements due to two entirely different kinds of causing forces. He abandons the terms "epeirogenesis" and "orogenesis" and calls any kind of tectonic movements on the earth *tectogenesis*. The type of movements which we so far have considered, the upward and downward oscillation of the surface of the earth constitute *primary tectogenesis* because these movements are the primary features without which all kinds of tectonic facts cannot be understood. Primary tectogenesis in the conception of Haarmann is only partly identical with epeirogenesis in the older sense.

The building of folded and overthrust mountain structures is the consequence of primary tectogenesis. All we know as folds, overfolds, overthrusts, faulting and similar processes is the result of gliding. No gliding can take place without an oblique base and therefore without preceding uplift, without primary tectogenesis. All these movements which eventually result in the building of faulted, folded, overthrust ranges constitute consequently *secondary tectogenesis*, which is in every case a gliding phenomenon and dependent upon the precedence of primary tectogenesis. Thus for the first time the attempt is made to connect causally the side-by-side existence of epeirogenetic and orogenetic or rather vertical and horizontal movements.

This theory explains also the existence of tension areas on the back side of overthrust ranges. Moreover the appearance of tension has to be expected behind a sedimentary complex gliding downward from the top of an uplifted dome. In this way fissures, magmatic intrusions and volcanic activity on the opposite side of the direction of the movement are satisfactorily explained. Also the rather common appearance of an arrangement of the mountain ranges in arcs is to be understood in the light of this theory.

In accordance with the different kinds of folding structures, Haarmann distinguishes several kinds of gliding. The first is *free gliding* ("Freigleitung") which takes place in not yet entirely filled geodepres-

sions where the gliding is not hindered by any obstacles. This kind of gliding has taken place in all the late-Tertiary mountain ranges and has caused folds, overfolds, overthrusts and the arclike outline of many of the ranges.

Secondly, there is *full-trough gliding* ("Volltroggleitung") which takes place in nearly filled geodepressions where not the whole sequence of sediments is able to glide, but only the upper strata, whereas compression with irregular movements and steep folds and faults appear in the deeper zones. Full-trough gliding may take place before free gliding and may thus add considerably to the complication of structures.

The third kind of gliding is *fault gliding* ("Bruchgleitung") which depends upon the existence of a competent surface of the sedimentary series and an incompetent gliding basis at the bottom. The results are downward movements of larger coherent blocks and dislocation along usually steep faults.

The fourth kind depends upon some special conditions and is called *squeeze gliding* ("Expressionsgleitung"). It applies to the only kind of secondary tectogenesis which does not take place as a downward but as an upward movement. Mobile members of the sedimentary series are squeezed and pressed up by the pressure of less plastic sediments. We see this process in deposits of clay, salt, coal, diatomite, ore and also sometimes in magmatic intrusions.

All these gliding processes take place in deeper zones, at least below sea level. The present height of the mountains is the result of later uplifting. Thus the former areas of geodepression have mostly assumed to-day the appearance of geotumors; on the other hand, the old geotumors in back of the present mountain ranges have to-day largely subsided and have become geodepressions and a new cycle of tectogenetic activity is going on.

Surface features of the moon seem to support Haarmann's ideas, the well known craters here being an equivalent to the geodepression of the earth.

Contrary to the view of Pickering and Wegener that the moon originated where now the Pacific ocean lies, Haarmann believes that we have to look for the original place of the moon rather where is now the greatest accumulation of sial material—in Asia. At the time when the moon was detached from the earth, the then already existing continental cores still had the ability to float and shift over the magmatic surface and filled up the hole left by the detachment of the moon's body. Afterwards, shifting of the continents could no longer take

place because it was prevented by the gradual cooling of the surface.

Some severe objections as to the possibility of application of Haarmann's ideas to some American problems have already recently been mentioned by C. R. LONGWELL[6] in a short review of Haarmann's book. Objections certainly will also come from the side of European geologists; but nevertheless nobody can and will doubt that Haarmann's book on diastrophism must be regarded as one of the most stimulating ones of the present time.

It may be noted that Haarmann, to his own advantage, could have made more use of E. O. ULRICH'S *Revision of the Paleozoic systems*. Ulrich was the first one to consider oscillatory movements as the primary feature of diastrophism, although he was more concerned with diastrophism as a factor in paleogeography. This side of the problem has not been given so much attention in Haarmann's book. The study of oscillatory movements in their combined effects on tectonics and paleogeography might prove one of the most promising efforts of future geology.

BOTANY.—*A new* Limonium *from Haiti.*[1] S. F. BLAKE, Bureau of Plant Industry.

One of the most interesting plants collected by Mr. and Mrs. EMERY C. LEONARD in their exploration of northwestern Haiti in 1928–29 is a species of sea-lavender (*Limonium*) which was found growing plentifully on the coral rocks and cliffs east of Bord du Mer, in the vicinity of Jean Rabel. No species of the genus is reported in Urban's *Flora Domingensis* (1920–21), and only two species have hitherto been found in the Bermudan-Bahaman-Antillean region. These are *Limonium lefroyi* (Hemsl.) Britton, treated by Britton in the Flora of Bermuda as identical with *L. carolinianum* (Walt.) Britton but in the writer's opinion a distinct species endemic in Bermuda,[2] and *L. bahamense* (Griseb.) Britton, a Bahaman endemic remote from any other described American species and most closely related to a group of the genus found in the Mediterranean region and southern Africa.[3] The plant from Haiti is closely related to *L. bahamense* and very similar to it in general appearance, but is well distinguished by its different bracts

[6] Am. Jour. Sci. **20**: 219–220. 1930.

[1] Received November 22, 1930.

[2] See Blake, Rhodora **18**: 54. 1916.

[3] Grisebach briefly compared his species with "*Statice caspia* Willd.," which it closely resembles in habit. If Boissier's series *Steirocladae* and *Hyalolepideae* are to be distinguished, however, both *L. bahamense* and *L. haitiense* are to be referred to the series *Steirocladae*, not to the *Hyalolepideae*, to which "*Statice caspia*" belongs.

and calyx. In *L. bahamense* the third bract of the spikelet is glabrous; the calyx is glabrous at the oblique base and short-pilose on two of the ribs from base for about half their length, and sometimes similarly pilose on one or two other ribs for a short space near their middle; and the upper half of the ribs is glabrous. In the Haitian plant the third bract is rather densely short-pilose above; the calyx is barbate-pilose all around at base, pilose with decidedly longer hairs (than in *L. bahamense*) on two of the principal ribs for about half their length and on the three other ribs near the middle, and similarly pilose to a greater or less extent on the very obscure intermediate ribs; and all five principal ribs are shortly pilosulous above the middle, sometimes nearly to the tip. The new plant may be called

Limonium haitiense Blake, sp. nov.

Limonio bahamensi affine, differt bractea tertia sursum pilosula, calycis basi piloso-barbati costis 2 e basi ad medium sublonge pilosis, 3 prope medium pilosis, omnibus supra medium saepe paene ad apicem breviter pilosulis.

Perennial, glabrous but obscurely scurfy; root rather short, vertical, with horizontal branches; stems very numerous and entangled, about 20 cm. long, leafy only below, divergently alternate-branched, articulate, angled, densely pustulate, the lower branches sterile, tipped with bracts like those of stem, only the uppermost branches floriferous; leaves spatulate, 2–5 cm. long including petiole (this often twice as long as blade), 3–8 mm. wide, obtuse or acute, cuspidate, cuneate at base, fleshy, somewhat lepidote-scurfy, 1-nerved; bracts of stem deltoid, acute, about 1.5 mm. long, with thick-herbaceous body and rather narrow scarious margin, glabrous; spikes numerous, corymbosely panicled, recurving, about 8–12 mm. long, the spikelets 3–4-flowered, densely and distichously imbricate; outermost bract suborbicular-ovate, rounded, glabrous, 2–2.5 mm. long, with subherbaceous body and rather broad scarious margin, the margin about half as broad as the width of the body; secondary bract hyaline, broadly and shallowly emarginate, about 1.7 mm. long; tertiary bract obliquely obovate in side view (suborbicular when flattened), rounded, rather densely spreading-pilosulous on upper half, 4.5 mm. long, with thick-herbaceous body and broad scarious margin (about 1 mm. wide); bracteoles elliptic-oblong, obtuse, glabrous, about 3 mm. long, hyaline throughout, the brownish costa evident only toward base or to above the middle; pedicels glabrous, 0.7 mm. long or less; calyx funnelform, 4–4.2 mm. long, whitish or lavender-tinged below, pilose-barbate all around at the oblique base, pilose from base to middle on 2 principal ribs, pilose near middle on the remaining principal ribs, pilose on one of the very indistinct intermediate ribs throughout its length and on the remainder at their tips, and very shortly pilosulous on the 5 principal ribs from middle often nearly to apex; calyx lobes deltoid, obtuse, about 0.5 mm. long, the intermediate teeth obsolete; petals apparently lavender.

HAITI: Common on coral rocks, shore cliffs east of Bord du Mer, vicinity of Jean Rabel, Dept. Nord-Ouest, 6 March 1929, *E. C. & G. M. Leonard* 13786 (type no. 1,452,380, U. S. Nat. Herb.); rocky cliffs east of Bord du Mer, 5 Feb. 1929, *Leonard & Leonard* 12881; dry coral rock, sea bluff east of Bord du Mer, 5 Feb. 1929, *Leonard & Leonard* 12889.

BOTANY.—*Five new grasses from Colombia.*[1] JASON R. SWALLEN, Bureau of Plant Industry. (Communicated by A. S. HITCHCOCK.)

Among the grasses collected by E. P. KILLIP and ALBERT C. SMITH in Colombia in 1926–27, four species are described as new. The fifth was collected by W. A. ARCHER in June, 1930, in Department Antioquia.

Chusquea tuberculosa Swallen, sp. nov.

Culmi dense tuberculosi, 6 mm. crassi, nodis pubescentibus vel villosis; vaginae papillosae; ligula minuta; laminae culmorum basi cordatae, 9–10 cm. longae, 3 cm. latae, ramorum fasciculatae minores, ovatae vel lanceolato-ovatae, glabrae, 2–3 cm. longae, 4–10 mm. latae, marginibus scabris; paniculae patentes, 7–10 cm. longae, 5–6 cm. latae; ramis divergentibus, dense pubescentibus; spiculae appressae, 6–7 mm. longae; glumae obsoletae vel minutae; lemmata sterilia duo, subaequalia, 5 mm. longa; lemma fertile acutum, 7-nervium, 6 mm. longum.

Culms woody and vine-like, solid, very densely and prominently tuberculate, more or less pubescent or villous at the nodes, as much as 6 mm. thick, bearing fascicles of sterile or flowering branches at the nodes, 5–30 cm. long; sheaths papillose-hispid to nearly smooth; ligule minute; blades of the main culm cordate-clasping, 9–10 cm. long, 3 cm. wide, those of the fascicled branches reduced, ovate or ovate-lanceolate, scarcely cordate, 2–3 cm. long, 4–10 mm. wide, all the blades smooth on both surfaces, scabrous on the margins; panicles open, 7–10 cm. long, 5–6 cm. wide, the branches stiffly spreading, the axis and branches densely soft-pilose; spikelets short pediceled, appressed, 6–7 mm. long; glumes obsolete; sterile lemmas two, subequal, 3-nerved, 5 mm. long; fertile lemma acute, 7-nerved, 6 mm. long.

Type in the U. S. National Herbarium, no. 1,353,497, collected on the edge of woods between California and Vetas, alt. 2500 m., Department Santander, Colombia, January 15–22, 1927, by E. P. KILLIP and ALBERT C. SMITH (no. 18005).

Known only from the type collection.

The prominently tuberculate culms are characteristic.

Neurolepsis mollis Swallen, sp. nov.

Culmi robusti, erecti, 1.5–4.5 m. alti; vaginae glabrae, in ore fimbriatae; ligula 1–2 cm. longa; laminae planae, 20–75 cm. longae, 2–4 cm. latae, petiolatae; panicula angusta, stricta, 0.45–1.5 m. longa, ramis pubescentibus, anguste ascendentibus, superioribus approximatis, inferioribus remotis; spiculae valde immaturae, 2 mm. longae, 3-florae, flosculis duobus inferioribus imperfectis; glumae subaequales, obtusae, quam spicula duplo breviores; lemmata firma, acuta vel cuspidata, scaberula.

Culms robust, erect from short knotty rhizomes, 1.5–4.5 m. tall; sheaths smooth, glabrous, at least the lower ones long-fimbriate at the mouth; blades flat, narrowed toward both ends, 20–75 cm. long, 2–4 cm. wide, sparsely pilose above, smooth below, scabrous on the margins, the bases of at least the lower

[1] Received October 5, 1930.

ones indurate and petiole-like, much narrower than the mouth of the sheath; ligule membranaceous, brownish, more or less lacerate above, 1–2 cm. long; panicles narrow, strict, 0.45 to more than 1.5 m. long, the spikelike branches appressed or narrowly ascending, the upper ones short and approximate, the lower distant, as much as 20 cm. long, these bearing rather distant fascicles of appressed branchlets, both the main axis and the branches densely and softly pubescent; spikelets (all immature) about 2 mm. long, three-flowered, the upper floret fertile, the lower two florets sterile; first and second glumes subequal, obtuse, more or less apiculate, about half as long as the spikelet; lemmas firm in texture, acute or minutely cuspidate, scaberulous.

Type in the U. S. National Herbarium, no. 1,351,648, collected in woods in the mountains east of Las Vegas, Department of Santander, Colombia, alt. 3000–3300 m., December 20–21, 1926, by E. P. KILLIP and ALBERT C. SMITH (no. 15830).

The only other specimen of this species seen is KILLIP and SMITH no. 20699, collected at Páramo del Hatico, alt. 2900 m., Department Norte de Santander, Colombia. As both specimens are immature the floral measurements of mature plants may be somewhat larger than those given. The soft dense pubescence on the axis and branches of the panicle is characteristic.

Muhlenbergia erectifolia Swallen, sp. nov.

Perennis caespitosa; culmi erecti, glabri, 15–20 cm. alti; folia basi aggregata; vaginae glabrae vel scaberulae; ligula acuta, 3–5 mm. longa; laminae erectae, rigidae, teretes, scabrae, pungentes, 5–10 cm. longae, basi quam vaginae angustiores; panicula angusta, 5–6 cm. longa, vix laminis longior; spiculae appressae, pedicellis crassis, 1–4 mm. longis; glumae aequales, truncatae, 1–1.3 mm. longae; lemma 2.5 mm. longum, infra pubescens supra scabrum; arista erecta, crassa, scabra, 3–5 mm. longa.

Densely tufted perennial; culms erect, 15–20 cm. tall, glabrous; leaves mostly crowded toward the base; sheaths smooth or somewhat scabrous; ligule membranceous, acute, 3–5 mm. long; blades erect, rigid, terete, scabrous, pungently pointed, narrower than the sheaths at the base, 5–10 cm. long; panicles narrow, erect, scarcely exceeding the blades, 5–6 cm. long, rather few-flowered, the branches appressed; spikelets appressed to the branches, the pedicels comparatively stout, 1–4 mm. long; glumes equal, 1–1.3 mm. long, truncate, more or less erose, tinged with bronze and purple; lemma 2.5 mm. long, somewhat pubescent below, scabrous toward the summit, tapering into a stout erect scabrous awn 3–5 mm. long.

Type in the U. S. National Herbarium no. 1,353,062, collected on Paramo de Santurbán, near Vetas, alt. 3,950–4,160 m., Department Santander, Colombia, January 17, 1927, by E. P. KILLIP and ALBERT C. SMITH (no. 17470).

Known only from the type collection.

The short terete, pungent blades are unlike those of any other species of this genus.

Panicum longiculme Swallen, sp. nov.

Culmi graciles, erecti vel decumbentes, ad nodos inferiores radicantes, 125 cm. longi, pilosi vel papilloso-pilosi, nodis barbatis; vaginae papilloso-pilosae;

ligula 1–2 mm. longa; laminae 2–5.5 cm. longae, 3–5 mm. latae, pubescentes, marginibus scabris; panicula 5 cm. longa, 4.5 cm. lata, ramis patentibus, axillis villosis; spiculae 2.4–2.6 mm. longae, pilosae; gluma prima acuta, 1–1.2 mm. longa.

Culms slender, wiry, erect or long-decumbent at the base and rooting at the lower nodes, as much as 125 cm. long, pilose or papillose-pilose, the nodes mostly densely retrorsely bearded; sheaths much shorter than the internodes, papillose-pilose; ligule hairy, 1–2 mm. long; blades flat 2–5.5 cm. long, 3–5 mm. wide with a white, scabrous, cartilaginous margin, softly pubescent on both surfaces; panicles few flowered, 5 cm. long, nearly as broad as long, the branches mostly widely spreading, the axis pilose; spikelets 2.4–2.6 mm. long, sparsely pubescent; first glume acute, 1–1.2 mm. long, 1-nerved; fruit pointed, equaling the second glume and sterile lemma.

Type in the U. S. National Herbarium, no. 1,444,529, collected in mountains above Bello, Quebrada del Ato, Department Antioquia, Colombia, June 17, 1930, by W. A. ARCHER (no. 160).

This species is allied to *P. venezuelae* Hack., but differs in having spikelets evenly distributed in the panicle, and fruit as long as the second glume and sterile lemma.

Ichnanthus angustifolius Swallen, sp. nov.

Probabiliter perennis; culmi graciles, glabri vel pubescentes, basi decumbentes radicantes, 110 cm. longi, internodis inferioribus brevibus, superioribus elongatis; vaginae pilosae vel papilloso-pilosae internodos aequantes vel 2–3-plo breviores; ligula obsoleta; laminae sublineares, acuminatae, pilosae, basi subcordatae, 7–9 cm. longae, 3–5 mm. latae; panicula longe exserta, 8 cm. longa, ramis ascendentibus vel patentibus, pilosis; spiculae 3.5 mm. longae, pilosae, appressae, solitariae vel binae; gluma prima acuta vel acuminata 1.8–3.5 mm. longa; gluma secunda acuta, lemma sterile aequans; lemma sterile obtusum; lemma fertile 2.4 mm. longum, basi appendicibus obsoletis.

Probably perennial; culms slender, straggling, long-decumbent at the base and with stilt roots at some of the nodes, more than 110 cm. long, glabrous, or sparsely pubescent, the lower internodes short, the upper ones elongate; lower sheaths as long as the internodes, the upper ones 1/3–1/2 as long as the internodes, pilose or papillose-pilose, especially on the margin and the collar; ligule nearly obsolete; blades linear or linear-lanceolate, acuminate, subcordate 7–9 cm. long, 3–5 mm. wide, pilose on both surfaces; panicle long-exserted, 8 cm. long, the axis and the ascending or spreading branches mostly short-pilose; spikelets 3.5 mm. long, more or less pilose or papillose-pilose, solitary or in pairs, appressed to the branches, the pedicel of the lower one of a pair less than 1 mm., that of the upper about 3 mm. long; first glume 3-nerved, acute or acuminate, from half as long to as long as the spikelet; second glume and sterile lemma equal, 5-nerved, the glume acute, the sterile lemma obtusish; fertile lemma 2.4 mm. long, the wings reduced to scars.

Type in the U. S. National Herbarium, no. 1,351,267, collected in woods, on the northern slope of Mesa de los Santos, alt. 1000–1500 m., Department Santander, Colombia, Dec. 11–15, 1926, by E. P. KILLIP and ALBERT C. SMITH (no. 15385).

Known only from the type collection.

The long-decumbent culms with stilt roots and narrow blades are typical.